EQUINE DENTISTRY

A PRACTICAL GUIDE

PATRICIA PENCE, DVM

Diplomat American Board of Veterinary Practitioners
Kimberly, Idaho

LIPPINCOTT WILLIAMS & WILKINS
A **Wolters Kluwer** Company
Philadelphia • Baltimore • New York • London
Buenos Aires • Hong Kong • Sydney • Tokyo

EQUINE DENTISTRY

A PRACTICAL GUIDE

ERRATUM

Equine Dentistry: A Practical Guide, written by Patricia Pence and published in 2002 by Lippincott Williams & Wilkins, includes a dosing error. In Chapter 3: The Dental Examination, on page 56, the dose of butorphanol is listed incorrectly. The fifth sentence in the second paragraph should read as follows:

"A commonly used mixture is 0.5 mg/kg xylazine plus 2 ug/kg detomidine HCl or **0.05 mg/kg butorphanol** at the start of the procedure, with injection of small amounts (0.5--0.75 mg/kg) of xylazine as needed to prolong sedation.[7]"

Please make note of this correction. The error will be corrected in future printings of *Equine Dentistry: A Practical Guide.*

EQUINE DENTISTRY

A PRACTICAL GUIDE

PATRICIA PENCE, DVM

Diplomat American Board of Veterinary Practitioners
Kimberly, Idaho

LIPPINCOTT WILLIAMS & WILKINS
A **Wolters Kluwer** Company
Philadelphia • Baltimore • New York • London
Buenos Aires • Hong Kong • Sydney • Tokyo

Editor: David Troy
Managing Editor: Dana Battaglia
Marketing Manager: Christine Kushner
Production Editor: Jennifer Ajello
Designer: Armen Kojoyian
Compositor: Maryland Composition
Printer: R.R. Donnelley & Sons-Crawfordsville
Cover Designer and Interior Designer: Karen Quigley

351 West Camden Street
Baltimore, MD 21201

530 Walnut Street
Philadelphia, PA 19106

Printed in the United States of America

Library of Congress Cataloging-in-Publication Data

Pence, Patricia.
Equine dentistry : a practical guide / Patricia Pence
p. ; cm.
Includes bibliographical references and index.
ISBN 0-683-30403-8 (alk. paper)
1. Horses—Diseases. 2. Veterinary dentistry. I. Title.
[DNLM: 1. Tooth Diseases—veterinary. 2. Horse Diseases. 3. Mouth Diseases—veterinary. SF 867 P397e 2002]
SF959.M66 P46 2002
636.1′08976—dc21

2001050306

To purchase additional copies of this book, call our customer service department at **(800) 638-3030** or fax orders to **(301) 824-7390.** International customers should call **(301) 714-2324.**

Visit Lippincott Williams & Wilkins on the Internet: http://www.LWW.com. Lippincott Williams & Wilkins customer service representatives are available from 8:30 am to 6:00 pm, EST.

01 02 03 04 05
1 2 3 4 5 6 7 8 9 10

To the horses who have been our workmates, companions, and friends through the centuries.

To the humans that recognize the suffering of this noble animal and devote their lives to relieving that suffering.

To my mother, Bernice Pence, may she rest in peace,
and to Russ for instilling in me the attitude
that I can accomplish anything that I set my mind to.

PREFACE AND ACKNOWLEDGMENTS

In the overall scheme of things, I am a Johnny-Come-Lately to equine dentistry. In 1993 I bought a small animal and equine practice in Meridian, Idaho. My equine clientele was somewhat sparse at first, so I could devote plenty of time to my examinations. I had floated horses' teeth before, with the traditional long-straight and long-angled floats. Usually they had dull carbide chip blades on them because I didn't know when they were supposed to be changed. Now that I owned my own clinic, the quality of work I produced mattered more than ever. Even without a full-mouth speculum, I could see that floating was not going to correct some of the abnormalities that I could see in the anterior part of the oral cavity.

In the same year I received a catalogue in the mail from World Wide Equine, then located in Nebraska. I read about the equine dentistry school and longed to go. However, my cash flow at that time couldn't support the tuition, airfare, hotel, and loss of a week's wages. What really caught my eye was the Dremel-powered dental instruments in the catalogue. I thought about purchasing them, but decided against it. I intuitively realized that an untrained person could do much damage with equipment like that.

It wasn't until 1995 that I purchased a battery-operated Makita reciprocating float. I was sure this was going to be an excellent compromise, but after awhile, I discovered that it was just an improvement over what I had been doing. I floated many horses' teeth with that machine. I did not consider it to be an instrument. I wore it out in about 9 months and had a friend rebuild it.

In March of 1996, I heard that Dale Jeffrey and World Wide Equine had moved to my neck of the woods in Idaho. I also heard that there was some grumbling among the local veterinarians about a non-veterinarian practicing dentistry. There were no veterinarians to my knowledge practicing that type of advanced equine dentistry in the entire state at that time. (My apologies to those that were, if you are out there.) My curiosity and interest in dentistry got the best of me, so I visited him at his new place of business in Glenns Ferry, Idaho. Dale gave me the grand tour of his facilities—the School for Equine Dentistry, the instrument manufacturing company, and the showroom of dental equipment. I admired his collection of 100-plus horse skulls and listened with interest to theories about how certain abnormalities are generated. I asked him if he would come to my clinic and give me a private lesson on the use of the Dremel-operated instruments and the various floats. He complied graciously. During that lesson, he informed me that he was going to the University of California at Davis, Veterinary School to participate in a weekend equine dentistry workshop for California graduate veterinarians. As soon as he left, I called and registered for the course and bought a plane ticket to Sacramento. After that weekend, I became, as one Idaho veterinarian called me, a horse dentistry evangelist. I have been preaching to anyone within earshot ever since.

Armed only with the 2 hours of instruction that Dale Jeffrey gave me plus the weekend at Davis, I purchased about $500 worth of power instrumentation and floats from Dale. I was the classic example of someone who knew "just enough to be dangerous." But I proceeded cautiously and erred on the side of being conservative. I had to re-do a few horses, but as far as I know, I didn't ruin the mouths of any. Ignorance is bliss.

I was disappointed in the lack of printed information on equine dentistry. I had written three chapters for an avian textbook, Diseases of Cage and Aviary Birds, for the editors, Drs. Rosskopff and Woerpel 6 years before, so I was no stranger to accepting difficult writing projects on subjects in which I was not an expert. I called Carroll Cann, the managing editor for the avian book at Williams & Wilkins and asked if he was interested in publishing a textbook on equine dentistry. Carroll liked the table of contents I submitted and encouraged me to go for it.

I had no intention of writing the whole book. I merely wanted to write a couple of simple chapters and engage experts in the field to write the more technical chapters. I eventually found out how naïve I was, both about the magnitude of the project and my lack of appeal as an editor with no credentials. Fortunately, Kristin Wilewski found my enterprising spirit and enthusiasm appealing. Without her agreeing to write four of the technical chapters, I never would have proceeded. She and I share the same attitude toward life: "Jump, and a net will appear," is the way she describes it. I am indebted to Kristin for dropping nearly everything to write those chapters. Two years later I revised and expanded her chapters using what she had given me as the framework.

The *#*&@! book project* as it came to be called, had many false starts and many hiatus periods. Lippincott-Raven merged with Williams & Wilkins. Editors came and went. One editor, Dana Battaglia, stayed. A year ago I was despondent about how little I had accomplished in the previous 2 years and begged her to let me out of my contract. She begged me to persist, saying that a practical guide was needed.

A practical guide is what I offer to the student of equine dentistry. I am aware that I referenced too little and that I have omitted or avoided areas in which others may consider vital. But I included practice tips and highlighted key points so that the important concepts would stand out. After the dust settles and criticisms and suggestions are collected, I'll take what I've learned and make the next edition an even more practical guide to equine dentistry.

Many thanks to the above mentioned people. I would also like to thank the following equine dental technicians for their guidance in my own learning and for providing invaluable information regarding technique for the book: Tony Basile, Lance and Steve Rubin, Larry Moriarity, and Carl Mitz.

Thanks also to the following veterinarians: Gordon Baker, for reviewing the paper I submitted (on the surgical removal of a horizontally impacted PM2) as part of my American Board of Veterinary Practitioners application back in 1995, to Tom Allen for his kind remarks and encouraging words after reviewing one of the earliest versions of the book, to Richard Miller, Scott Greene, David Klugh, Randi Brannan, and Russ Tucker for reviewing chapters and providing suggestions. Thanks to Dale Jeffrey, Clay Stubbs, Harold Conrad, and Dennis Rach for providing photographs of instruments. Thanks also to Kevin May, Paulo Zaluski, Lloyd Jeffrey, and Lynn Caldwell just because you are nice to have around.

I'm sure I omitted someone who deserved my thanks. I hope to thank you later in person.

CONTRIBUTORS

PATRICIA PENCE, DVM
Diplomat American Board of Veterinary Practitioners
Kimberly, Idaho

KRISTEN WILEWSKI, DVM
International Association of Equine Dentists/Examiner
Poplar Grove, Illinois

TONY BASILE
Master Equine Dental Technician
International Association of Equine Dentists/Examiner
St. Helens, Oregon

SCOTT GREENE, DVM
International Association of Equine Dentists/Certified Advanced
Sparks, Nevada

CARL MITZ
Equine Dental Technician
International Association of Equine Dentists/Certified
Brenham, Texas

CONTENTS

Preface

CHAPTER 1 Dental Anatomy 1
Patricia Pence

CHAPTER 2 Dental Equipment 25
Patricia Pence

CHAPTER 3 The Dental Examination 53
Patricia Pence

CHAPTER 4 Basic Dental Techniques 79
Kristin A. Wilewski, Scott Greene, Tony Basile, Patricia Pence

CHAPTER 5 Newborn, Weanling, and Adolescent Horse Dentistry 115
Patricia Pence and Kristin A. Wilewski

CHAPTER 6 The Mature Horse 141
Patricia Pence and Kristin A. Wilewski

CHAPTER 7 The Geriatric Horse 169
Patricia Pence and Kristin A. Wilewski

CHAPTER 8 Miniature Horse Dentistry 191
Patricia Pence and Carl Mitz

CHAPTER 9 Basics of Diagnostic Imaging 201
Patricia Pence and Tony Basile

CHAPTER 10 Dental Infections: Pathology and Treatment 209
Patricia Pence

CHAPTER 11 Extractions 231
Patricia Pence

CHAPTER 12 Marketing the Equine Dental Practice 241
Patricia Pence

Color Plates

APPENDIXES A: Equine Dental Equipment and Instrument Suppliers 259
B: Spare Parts Commonly Needed in Dremel Instruments 263

Glossary 251
Index 265

1

DENTAL ANATOMY

PATRICIA PENCE

The dentition of the horse is characterized by hypsodont teeth. Long crowns; short, late-forming roots; and no identifiable crown-root junction are defining features. Eruption is prolonged and facilitated with deposition of bone at the bottom of the alveolar socket as attrition occurs at the occlusal surface Bone 1. In comparison, humans, carnivores, and swine have brachydont teeth. The brachydont tooth is characterized by a distinctive crown, neck, and root. Enamel is restricted to the crown, and the tooth discontinues growing when the tooth is fully erupted.

Knowledge of the anatomy of normal dental and associated structures is necessary for the dental practitioner to be able to recognize, diagnose, and treat dental disease. An educated eye is needed to be able to identify pathology in individual teeth, whether that be identifying a supernumerary tooth, identifying a tooth with abnormal conformation, or differentiating caries from nonpathological discoloring. Imaging modalities used to differentiate between dental and nondental disease, i.e., radiology, computed tomography, magnetic resonance, and ultrasonography, depend heavily on a working knowledge of anatomy. For dental disease that requires surgical treatment, awareness of important structures that are in close apposition to the teeth is vital so that those structures may be protected from damage.

Understanding dental physiology is needed to appreciate how heavily mastication depends on normal anatomy. The practical implications of both anatomy and physiology are these: abnormalities in the height, shape, or composition of individual teeth can have profoundly negative effects on the dental system as a whole, as will be illustrated in later chapters.

This chapter will introduce the following basic concepts important to the understanding of normal anatomy of the equine dental system: the evolution of the dental system of the horse, embryology and development, nomenclature, and the gross and applied anatomy of dental and associated structures. The chapter also describes the physiology of the dental system as it applies to mastication.

EVOLUTION OF THE EQUINE DENTAL SYSTEM

The equine head and teeth illustrate the response of a species to evolutionary demands. The first known ancestor of the horse, Hyracotherium (also known as Eohippus), lived during the Lower Eocene period in South America.[1,2] It was a fox-sized creature that looked more like a small, hornless antelope than a modern horse. The face of this tiny creature was short, and the large eyes were set near the middle of the head. This primitive relative of the horse lived in jungles and forests and ate the soft, succulent vegetation that proliferated in the tropical climate of that period. The cheek teeth were smaller and simpler than those of modern equids.

After the Middle Miocene period, the environment and the diet of this creature changed. The earth's climate became cooler and dryer. The succulent, leafy plants were replaced by coarse, hardy grasses containing a high silica content. The teeth of the surviving descendants of Hyracotherium evolved to withstand the constant wear they were subjected to by a diet of abrasive grasses; such evolution allowed the animal to live long enough to maintain itself through the reproductive years. The skull became longer and deeper to accommodate the taller tooth crowns and larger teeth. The premolars became more complex and eventually became molars, creating a continuous grinding surface from the first to the last cheek tooth of each arcade.[1,2] Composed of elaborate patterns of cementum and dentin vertically folded with enamel, the cheek teeth became a lifelong supply of crown anchored by small roots. This folding created a self-sharpening grinding surface on the occlusal aspects of the cheek teeth and formed exaggerated sulci on the buccal surfaces of the maxillary teeth. Delayed maturation of the roots allowed the reserve crown to continue to grow after the exposed crown came into wear.

Another significant change was the development of an organ, the cecum, in which intestinal microbes digested plant material high in cellulose. Such coarse plant material needed to be ground into smaller particles for the horse than for ungulate species because the horse could not eructate its food back into the oral cavity for further chewing.

Approximately 5000 years ago, man domesticated the horse, changing its environment and diet considerably.[3] As human's environment changed from free-roaming and pastoral to agrarian and now, in many parts of the world, to urban, so did the environment and, more important, the diet of human's workmate and companion, the horse.

Horses kept in pens or stalls are fed twice a day and may spend only 4 hours a day grinding food, compared to the 16 or more hours a day that a pastured horse may spend grazing. The high silica plains grasses have been replaced by tender pasture grasses that are not as abrasive. Hay, hay cubes, and pelleted feed are picked up by the lips and by-pass working the incisors completely. The resulting lack of normal wear allows overgrowth of the incisors. Grain and pelleted feeds require shorter lateral–medial masticatory movements, thereby preventing use of the total molar grinding surfaces.[4] These unworn surfaces become sharp, overhanging edges on the buccal sides of the maxillary teeth and the lingual sides of the mandibular teeth.

DEVELOPMENTAL ANATOMY

The embryonic mouth forms from an indentation of the ventral surface of the embryo at the level of the first branchial arch. An identifiable mouth cavity is present by the first 3 weeks in most species. At approximately 3½ weeks of age, a horseshoe-shaped band of cells appears composed of the ectodermal epithelium that lines the mouth. This band of cells forms two ridges, the vestibular lamina and the dental lamina. The vestibular lamina gives rise to the lips and gingiva. The dental laminae invaginate at predetermined intervals to create the first tissue of tooth formation, the enamel organ.[5–9]

The early development of hypsodont teeth is similar to branchydont teeth.[8,10] The enamel organ develops through a series of stages, differentiated by the shape of the enamel organ and the type of cells composing it. The initial invaginations of dental laminae, composed of ectoderm, mark the bud stage of the enamel organ. Deciduous tooth buds form first. Shortly thereafter, permanent tooth buds arise from the tissue that form the deciduous buds. During the next stage, the cap stage, the bud grows and forms a slight concavity. At this time, the enamel organ has three layers, all still ectoderm in origin. The enamel concavity deepens as the third, or bell stage, is entered. From this point on, the shape of the enamel organ depends on the type of tooth it is destined to become.

The individual layers of tooth tissue form during the bell stage. The cell layer lining the inside of the bell differentiates into ameloblasts at the apex and cementoblasts at the base. Eventually, the ameloblasts form the enamel layers, and the cementoblasts form the layers of cementum. The cells adjacent to the base of the bell originate from mesenchymal epithelial cells. These mesenchymal cells will align themselves against the epithelial cells lining the bell and differentiate into odontoblasts, which will form the dentin and pulp layers of the tooth. The odontoblasts and pulp are collectively called the dental papilla.

The enamel organ of hypsodont cheek teeth folds into a series of longitudinal cylinders that continue to grow distally *(Fig. 1.1)*.[10,11] When the tooth reaches its maximum length, the enamel organ covering the more mature, mineralized apical portion of the tooth degenerates. Distally, it continues to grow into the dental sac.

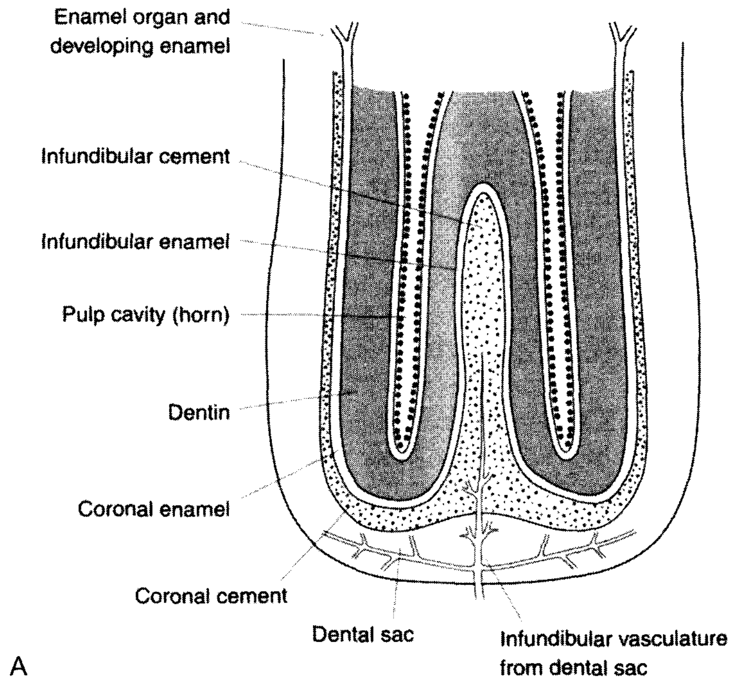
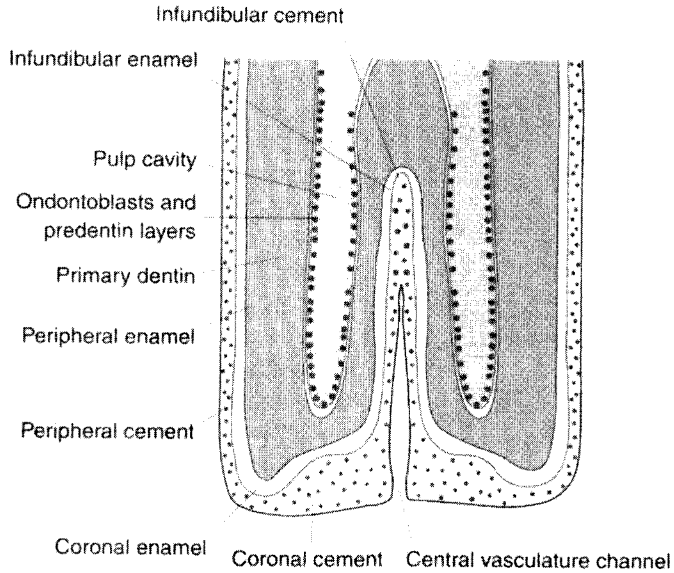


Figure 1.1 The crown and occlusal surface of a multicusped hyposodont tooth with an infundibulum (i.e., an upper cheek tooth). A. Immediately prior to eruption. B. Immediately following eruption, showing loss of the dental sac over the occlusal surface. C. Following wear of the primary occlusal surface to expose the secondary occlusal surface that is the permanent occlusal surface in hyposodont teeth. (Reprinted with permission from: Baker GJ, Easley J. Equine Dentistry. Philadelphia: WB Saunders, 1999.)

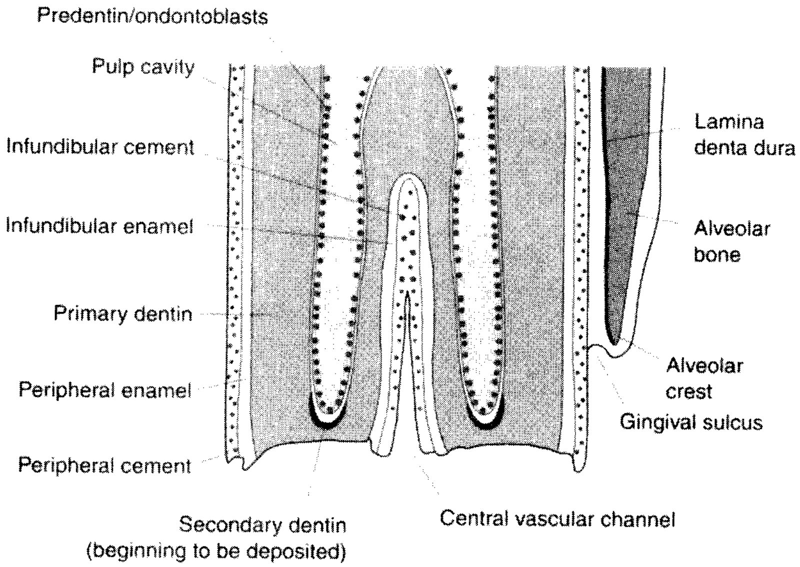
The entire dental sac surrounding the hypsodont tooth differentiates into cementoblast cells, whereas only the layer of cells adjacent to the forming root become cementoblasts in the brachydont tooth. This complex will form a deciduous tooth.[11]

Deciduous teeth play an important role in dental development.[12] They act as guides for the proper placement of the permanent teeth. Therefore, their premature loss or delayed expulsion can cause maleruption or impaction of the permanent teeth. Permanent incisor and premolar teeth arise from the tissue of deciduous teeth. If the deciduous tooth bud does not form, no tooth will grow in its place.

Except for molars (teeth #9, 10, and 11), permanent teeth form from tissues of the deciduous teeth. The follicles of the developing permanent incisors lie lingual to the deciduous roots. The permanent premolar follicles lie within the bifurcation of the deciduous premolar roots.[10] The 12 molar teeth have no deciduous counterpart and branch directly off the dental lamina.[11] Pressure by the crown of the permanent tooth on the root of the decidous tooth causes resorption of the deciduous root. Re-



B



C

Figure 1.1 *Continued.*

TABLE 1.1 Eruption Schedule

	Tooth	0–1year	1 year	2 years	3 years	4 years
Incisors	D #1	1st week	—	—	—	—
	#1	—	—	2 years, 6 months	—	—
	D #2	2 months	—	—	—	—
	#2	—	—	—	3 years, 6 months	—
	D #3	8 months	—	—	—	—
	#3	—	—	—	—	4 years, 6 months
Canines	#4	—	—	—	—	4 years to 4 years, 6 months
Wolf Teeth	#5	6 months to 1 year				
Premolars	D #6	1st week	—	—	—	—
	#6	—	—	2 years, 8 months	—	—
	D #7	1st week	—	—	—	—
	#7	—	—	2 years, 10 months	—	—
	D #8	1st week	—	—	—	—
	#8	—	—	—	3 years, 8 months	—
Molars	#9	—	1 year	—	—	—
	#10	—	—	—	—	—
	#11	—	—	2 years	—	4 years

D = deciduous teeth
Note: This table serves as a guideline only. Some variation occurs between breeds.

sorption begins at the apical extremity of the tooth and continues in the direction of the crown until resorption of the entire root has taken place. The crown, which then loses its attachment owing to lack of support, is exfoliated during mastication.

Between the ages of 2½ years and 5 years, the dentition of the young horse is in a dynamic state. Twenty-four deciduous teeth will be shed, and 40 permanent teeth will erupt *(Table 1.1)*.

KEY POINT

▶ **Premature loss or injury to deciduous teeth may cause permanent teeth to erupt in abnormal positions, be abnormally shaped, or fail to erupt at all.**

NOMENCLATURE

Dental Formulae

The denomination and number of teeth are described by the dental formula. Each tooth is represented by its first initial, I for incisor, C for canine, P for premolar, and M for molar, followed by the number of each type of tooth. The number of maxillary teeth is placed on a line above the number of mandibular teeth. The numbers of both are totaled, giving the number of teeth on one side of the mouth. Logically, doubling this number will give the total number of teeth. There are separate dental formalae for the deciduous teeth and the permanent teeth.

The **deciduous dental formula** for the horse is (I3/3 P3⁄3) × 2 = 24.

The **permanent dental formula** for the individual horse is variable, (I3/3 C1/1 P3 or 4/3 M3/3) × 2 = 40 to 44, depending on whether canine teeth and wolf teeth are present.

Tooth Surfaces

The surfaces[12] of the incisors and canines facing the lips are called the labial surfaces *(Fig. 1.2A, B)*.

The surfaces of the cheek teeth in contact with the mucous membranes of skin overlying them are called the buccal surfaces. The tooth surfaces in contact with the tongue are called the lingual surfaces. The surfaces of the premolars and molars that contact those of the opposite jaw during the act of closure are called occlusal surfaces. In incisors, these contact surfaces are called incisal surfaces. The coronal portion of a tooth is the exposed crown. The reserve crown is the portion of the crown that is unexposed, i.e., below the gingival margin. The apical portion of a tooth is toward its root. This term is used to describe the reserve crown. The marginal border of a tooth is at the tooth–gingival interface.

The median line is drawn vertically between the central incisors at their point of contact with each other in both the maxilla and the mandible. The surfaces of teeth

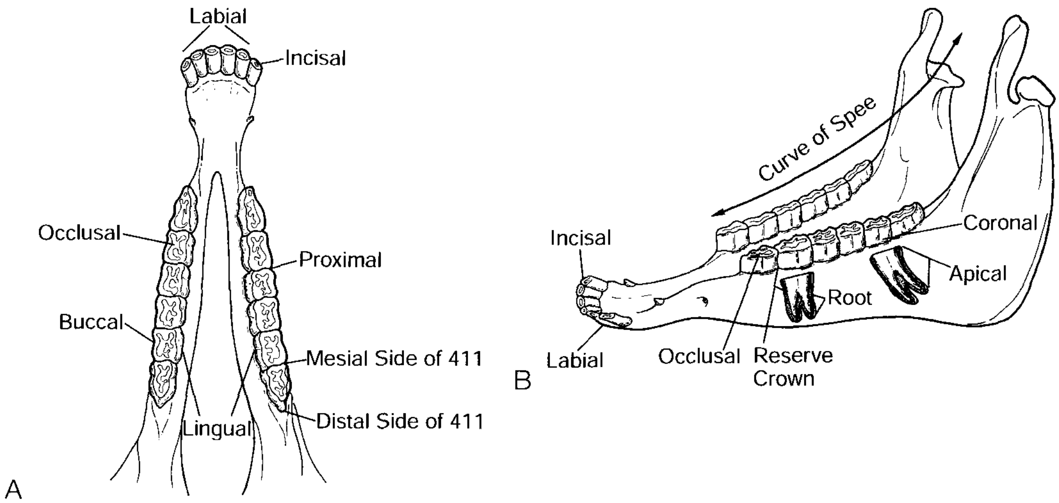


Figure 1.2 **A.** Dorsal view of the mandibular dental arch identifying tooth surfaces. **B.** Lateral view of the mandible, identifying tooth surfaces.

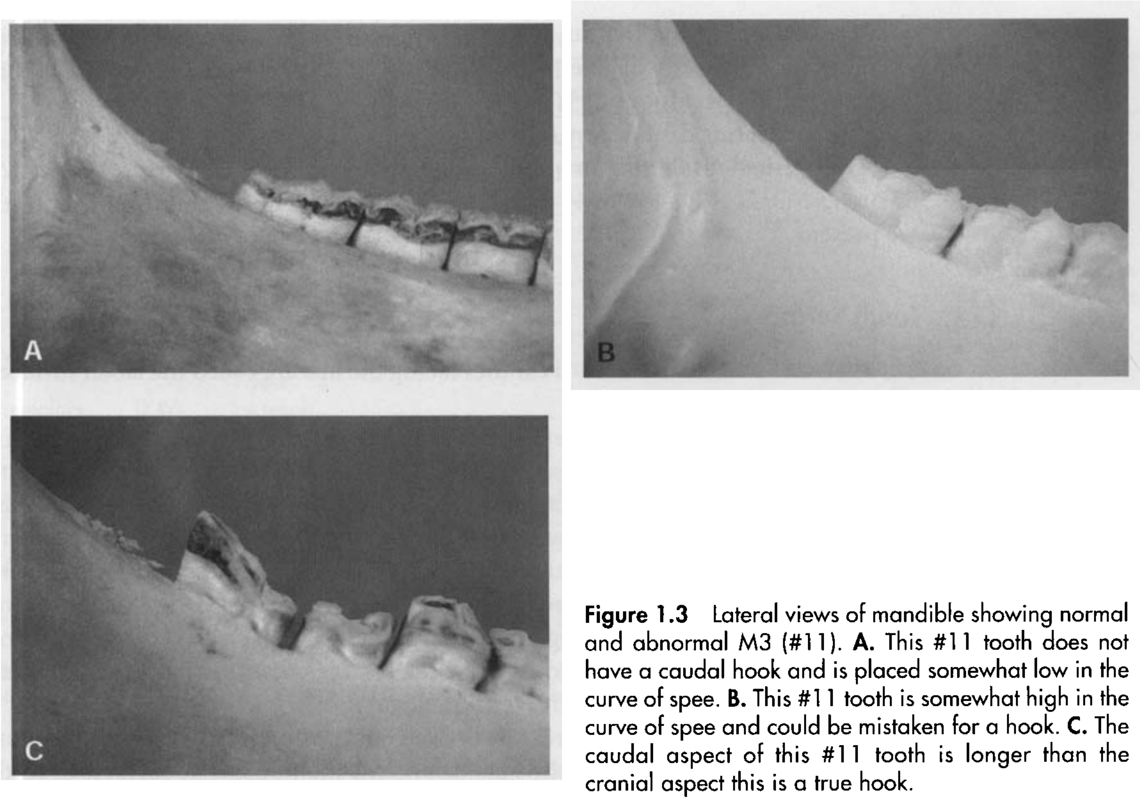


Figure 1.3 Lateral views of mandible showing normal and abnormal M3 (#11). **A.** This #11 tooth does not have a caudal hook and is placed somewhat low in the curve of spee. **B.** This #11 tooth is somewhat high in the curve of spee and could be mistaken for a hook. **C.** The caudal aspect of this #11 tooth is longer than the cranial aspect this is a true hook.

facing toward adjoining teeth in the same dental arch are called proximal surfaces. The proximal surfaces can be either mesial, the surface closest to or facing the median line, or distal, the surface farthest or facing away from the median line. The mesial surfaces of the cheek teeth are also referred to as rostral surfaces.

The curve of Spee is the anatomic curvature of the mandibular occlusal plane, beginning at the rostral surface of the second premolars (#06), following the buccal edges of the cheek teeth, and continuing to the anterior ramus of the mandible *(Fig. 1.3A–C)*. Knowledge of the existence of the curve of Spee becomes important when trying to differentiate between malocclusive and normal conditions of the last lower molars.

Numbering Systems

Numbering systems are used to identify individual teeth for record-keeping purposes. Currently, there are three numbering systems: the standard system, the cheek teeth system, and the modified Triadan system.

Standard System. The standard system is the one most familiar to veterinarians and students of anatomy. Each type of tooth is identified by the upper case letter assigned to it in the dental formula followed by a number assigning its position in the mouth relative to the median line *(Fig. 1.4A, B)*. Beginning with the incisors, the center incisors are called I1, the second incisors from the center are called I2, and the corner incisors I3. The first premolar, the wolf tooth, is called PM1, and the first cheek tooth is called PM2, etc. The drawback to this system is that confusion still exists about which specific tooth is being referred to unless it is separately specified whether the tooth is in the mandibular jaw or maxillary jaw, and on the right or left side.

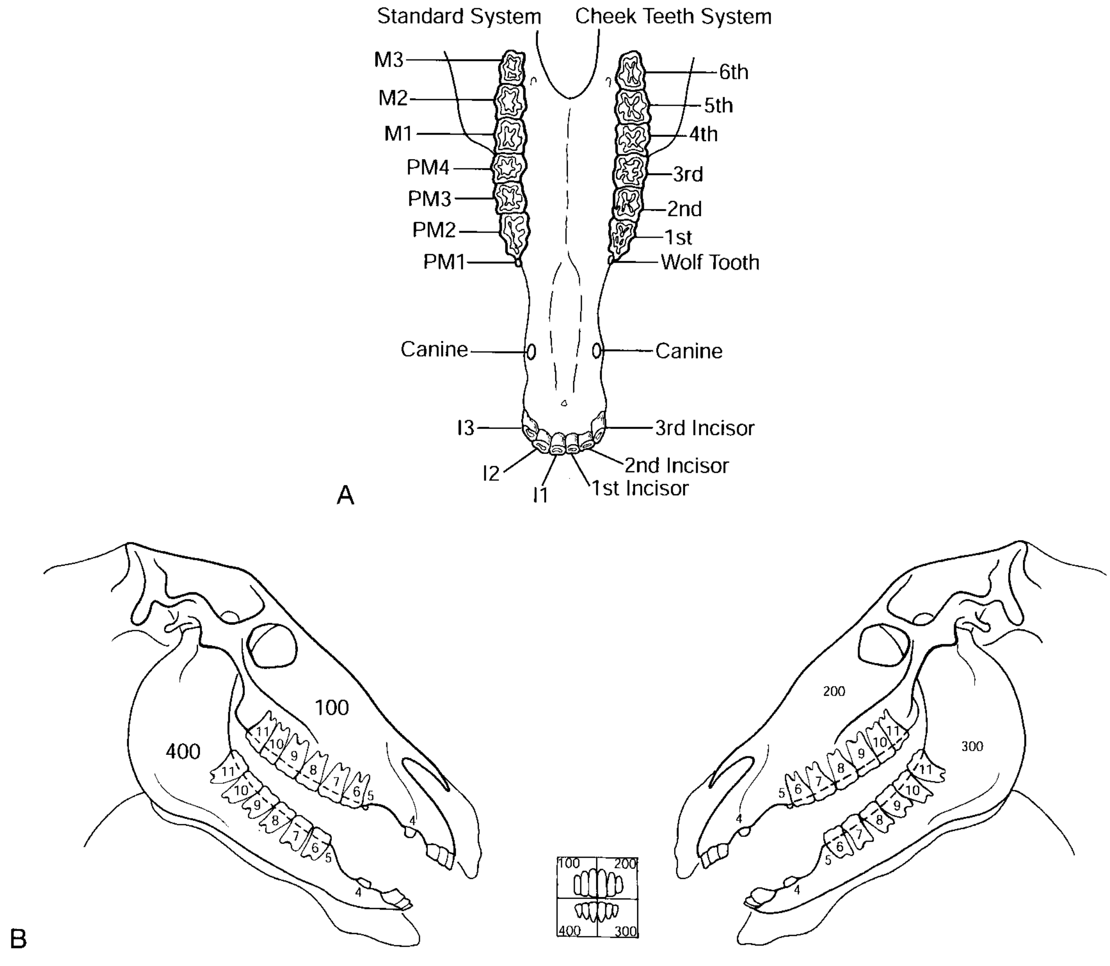


Figure 1.4 **A.** The standard and cheek teeth numbering systems. **B.** The Triadan numbering system is based on a full phenotypic dentition of 44 teeth. The teeth are numbered by quadrant and by tooth position. Upper right (quadrant 1), upper left (quadrant 2), lower left (quadrant 3), lower right (quadrant 4). Tooth position starts with numbering the central incisors #1. The canines are #4, the wolf teeth are #5, the first cheek teeth are #6, and the last cheek teeth are #11.

Cheek Teeth System. The cheek teeth system is similar to the standard system in that the incisors are numbered the same. However, the premolars and molars are referred to by number only, and the wolf teeth are not included as cheek teeth. The second premolar is called number one, the third premolar is called number two, and so on, ending with number six, the third molar *(Fig. 1.4A)*. A separate description must be added to identify whether the tooth is maxillary or mandibular, right or left.

Modified Triadan System. A third system, the modified Triadan numbering system, is becoming a more universal system of classifying individual teeth *(Fig. 1.4B)*.[13] This system divides the mouth into quadrants, to specify whether an individual tooth is in the upper or lower jaw and whether it is on the right or left side.

Moving clockwise, the right maxilla is called quadrant number one, and the teeth are labeled in the 100 series. Next the left maxilla is called quadrant number two, and the teeth are in the 200 series. Then follows the left mandible, called quadrant number three, and the teeth are in the 300 series; and the right mandible is called quadrant number four, and the teeth are in the 400 series. The teeth are then assigned another number according to their position relative to the median line, starting with the central incisor in that quadrant. Therefore, the first incisor is number one, the canine is number four, the wolf tooth is number five, and the last molar is number eleven.

ANATOMY

Anatomically, the dental mechanism is designed to promote structural integrity and thereby prolong its own life. This structural integrity is maintained by the length and shape of the reserve crown, the angle at which occlusal surfaces are placed relative to the reserve crown and roots, adequate tooth substance for strength, and a biomechanical design that produces solidity with resistance against lines of force. The impressive mass of reserve crown relative to exposed crown anchors the tooth securely within its socket.[11] Although the incisors and cheek teeth are separated by the interdental space, each tooth within its group lies in close apposition to its neighbor. This tight arrangement helps stabilize the dental arches by the combined anchorage of all the teeth within each group and prevents food from lodging between the teeth and damaging the periodontium. The corner teeth, i.e., the third incisors (1/3, 2/3), the second premolars (1, 2, 3, 4/6), and the third molars (1, 2, 3, 4/11), are protected from drifting by the angle of direction of occlusal forces being in their favor and by the angulation of their occlusal surfaces with their roots.

Composition of Equine Teeth

Dentin. Equine teeth are composed primarily of dentin, a cream-colored substance composed of calcified tissue secreted by odontoblasts. The odontoblasts have their cell bodies in the pulp tissue and have long cytoplasmic processes that extend into the mineralized dentin tubules.[14] Approximately 70% of this tissue is mineral, primarily hydroxyapatite crystals. The remaining 30% is composed of collagen proteins, mucopolysaccharides, and water. The organic components give dentin the properties of elasticity and compressibility, which, as mentioned, helps protect the more brittle enamel components of equine teeth.

There are four types of dentin.[4] Primary dentin is produced during tooth development. Secondary dentin is deposited on the walls of the pulp canal and in the cytoplasmic processes. Tertiary dentin is produced to keep the pulp from being exposed as the occlusal surface is worn or as the result of an injury. Sclerotic dentin is produced in response to mild irritation.

KEY POINT

▶ **Dentin protects the pulp from bacterial invasion as the pulp canal is exposed by wear.**

Cementum. Cementoblasts produce cementum. Cementum covers the entire external surface of the tooth prior to eruption and fills the infundibuli of maxillary teeth and incisors. Similar to dentin in composition, cementum is approximately 65% mineral, 35% organic material, and water.[15] Supragingival cementum has no blood supply after eruption and serves to fill in surface irregularities and to protect the enamel. Subgingival cementum is part of the peridontal ligament complex and is living tissue. Cementoblasts in the alveolus secrete cementum in response to tooth eruption and to infection or injury.

Enamel. Enamel is the hardest substance in the body. Secreted by ameloblasts, enamel is approximately 98% hydroxyapatite crystals and 2% keratinous proteins. Enamel is an inert substance, not a living tissue, and therefore cannot reproduce or repair itself. The high mineral content of enamel gives this substance high tensile strength but also makes it brittle. Supporting layers of dentin and cementum absorb the shock applied to teeth and prevent the enamel from chipping and cracking. This layering of dental substances protects the enamel and enables the exposed edges to act as self-sharpening blades to shred roughage.

Electron microscopic examination of sections of teeth has shown equine enamel to have different structures depending on where in the tooth it is laid down.[16] Three types of equine enamel have been described and classified according to the structure and arrangement of the hydroxyapatite crystals.

KEY POINT

▶ **The brittle enamel layer is protected from shattering by support from the more elastic dentin and cementum layers.**

Pulp. Pulp is a loose connective tissue composed of arteries, veins, nerves, lymphatics, odontoblasts, and fibroblasts that occupies the pulp cavity of the tooth.[4] Its primary function is to support and nourish the dentin-producing odontoblasts. Pulp's extensive nerve supply gives the tooth sensory capabilities, thereby giving the tooth defensive capabilities. When irritation is detected, the odontoblasts respond by secreting dentin to protect the injured area.[12]

Incisors. The incisors of horses are used to nip and tear off forage and for defense. Incisors have a single enamel-lined infundibulum that presents at eruption as a cup in the incisal surface. As the tooth is worn down, the infundibum tapers to a white spot of enamel that is lost to attrition when the horse is approximately 15 years old *(Fig 1.5)*.[17]

The roots of incisors contain a single pulp canal and terminate in a single apex. The pulp canal fills with secondary dentin when wear or injury exposes it.

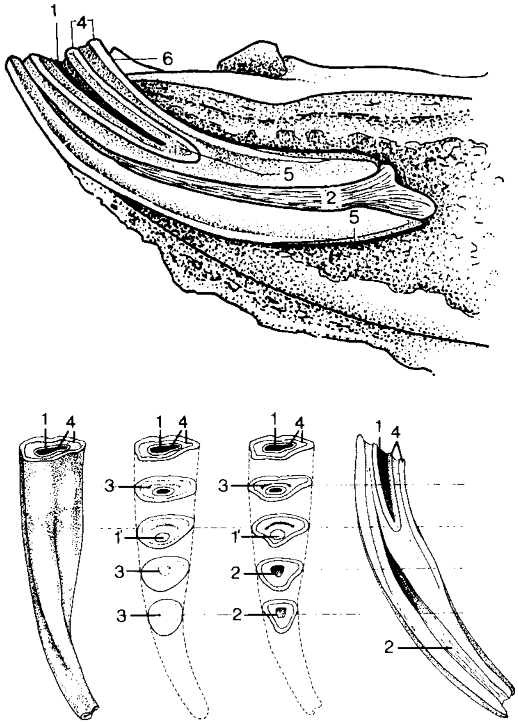


Figure 1.5 Structure of a lower incisor. *A, In situ,* sectioned longitudinally; the clinical crown is short in relation to the embedded part of the tooth. *B,* Caudal view; the junction between the clinical crown and the rest of the tooth is not marked. *C,* As a result of wear the occlusal surface changes; the cup gets smaller and disappears, leaving, for a time, the enamel spot; the dental star appears and changes from a line to a large round spot. *D,* These are sawn sections of a young tooth for comparison. *E,* longitudinal section of incisor, showing the relationship between the infundibulum and dental cavity; the latter is rostral.

The shape of the incisal surface and the exposed crown changes from oval, to round, then finally triangular as attrition occurs.[18] The angle of eruption also changes with age and wear because the curve of the reserve crown is flatter than the crown initially erupted. The incisors of the young horse erupt in an almost vertical fashion. As the horse matures, the angle diverges more toward the horizontal.

The upper corner incisors may have a vertical groove in the center of the labial surface. This landmark, known as Galvayne's groove, appears at approximately age 10, extends the length of the tooth at approximately age 20, will be half gone sometime near age 25, and will be completely gone by approximately age 30.[16,19] This groove is not always present and can be hard to see unless it is discolored.

Distinct differences between the deciduous and permanent incisors exist that assist aging the horse by incisor eruption and wear. Deciduous teeth are smaller and whiter, have a constricted neck, and are well-worn. Deciduous teeth do not have an infundibulum. Permanent teeth are larger, are covered by yellowish cementum, have no identifiable neck, and have distinct vertical ridges.

KEY POINT

- **Anatomical landmarks on incisors have been used for centuries to estimate the age of horses.[19]**

Canine teeth. Canine teeth are used for fighting and are usually found only in male horses. Male horses usually have one canine tooth per arcade in the large interdental space between the incisors and molars. Sometimes one or more are missing, or rarely, there is more than one in an arcade. Occasionally, female horses erupt canine teeth, but they are usually only in the mandible and are very small *(Fig. 1.6)*. Canine teeth have a large root that comprises ⅔ to ¾ the length of the tooth.

It is common for canine teeth to be thickly coated with tartar, which can cause mild-to-moderate periodontal disease at the gingival margin.

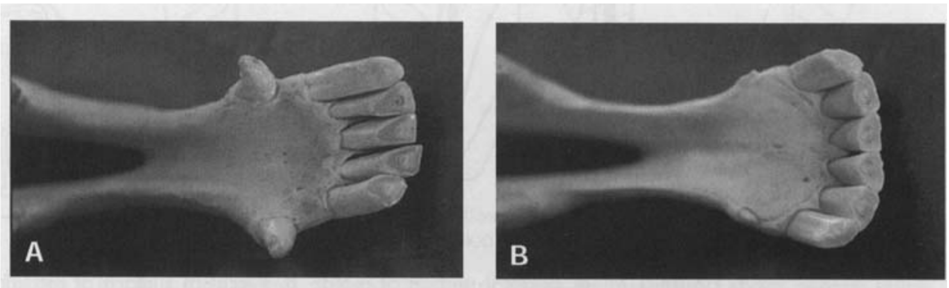


Figure 1.6 **A.** Canine teeth in a mature male horse. **B.** Canine teeth in a mature female horse.

Wolf teeth. The first premolar, commonly called the wolf tooth, is a small, rudimentary tooth. Usually present in both sides of the maxillary arcade in close proximity to the first cheek teeth, these teeth have distinct necks and roots. Wolf teeth may be found more cranially in the interdental space, may be found in the mandibular arcade, there may be more than one per quadrant, they may present as unerupted teeth, and they may be completely absent. Wolf teeth also vary in size of crown and root and, not surprisingly, ease of extraction.

KEY POINT

▶ **The palatine artery lies in close proximity (2 to 3 mm medial) to the lingual gingival margin of the maxillary teeth and must be avoided when teeth are extracted.**

Cheek teeth. The cheek teeth are designed to be continuously erupting, self-sharpening grinders. This self-sharpening is facilitated by the presence of enamel-lined infundibuli in the maxillary arcades *(Fig. 1.7)*. A layer of cementum fills the infundibulum and folds with layers of enamel and dentin to form lophs. These

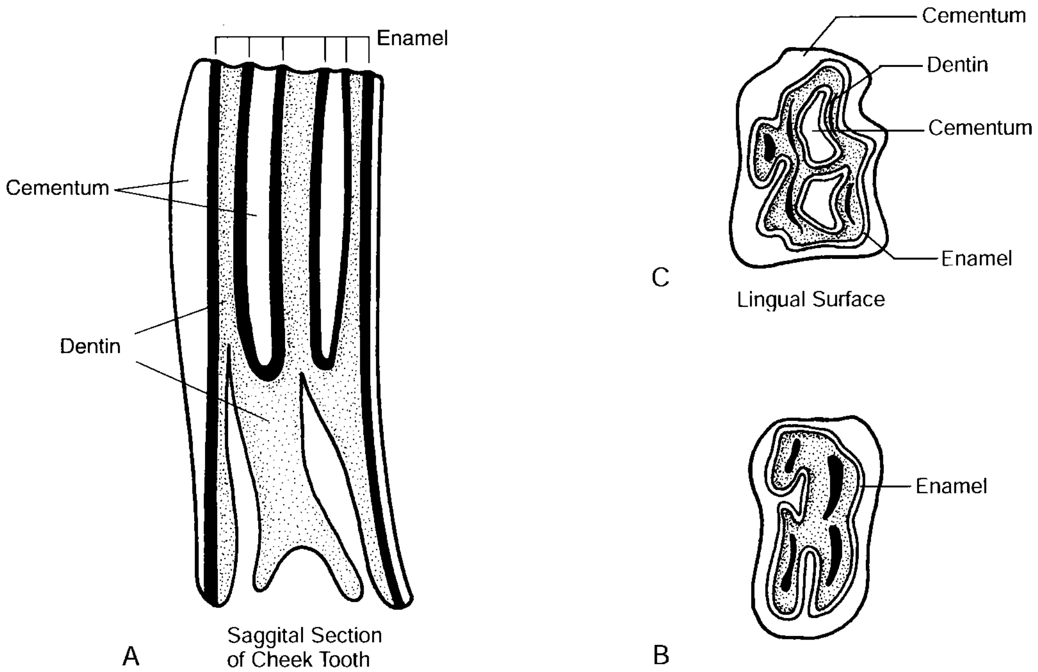


Figure 1.7 **A.** Sagittal section of molar. **B.** Occlusal surface of maxillary tooth. **C.** Occlusal surface of mandibular tooth.

different dental substances wear at different rates, resulting in an irregular occlusal surface.

KEY POINT

▶ **The occlusal surface wears away at a rate of 2 to 3 mm per year.[20] The horse's diet and the presence of sand in the food may alter this rate.**

The 12 decidous premolars (#6, 7, and 8) are erupted at birth or within the first week. These temporary teeth shed at approximately 2 years, 8 months; 2 years, 10 months; and 3 years, 8 months of age. The permanent molars (# 9, 10, and 11) erupt at approximately 1, 2, and 3.5 years of age.

The upper and lower cheek teeth have several distinct anatomical differences. Maxillary cheek teeth have two infundibuli, but the mandibular teeth have none. The maxillary teeth are more wide and square than the mandibular teeth and have pronounced longitudinal ridges on their buccal aspects. These enamel ridges can be very sharp on their ventral corners and are the source of a great deal of discomfort. The mandibular teeth are more narrow and oblong and do not have longitudinal ridges (*Fig. 1.8A,B*).

At eruption, the permanent cheek tooth consists of an exposed crown, a reserve crown with a widely dilated apex, and 5 or 6 pulp horns that connect to a pulp chamber in the reserve crown. Root walls are immature, consisting of just a thin plate of enamel.[21]

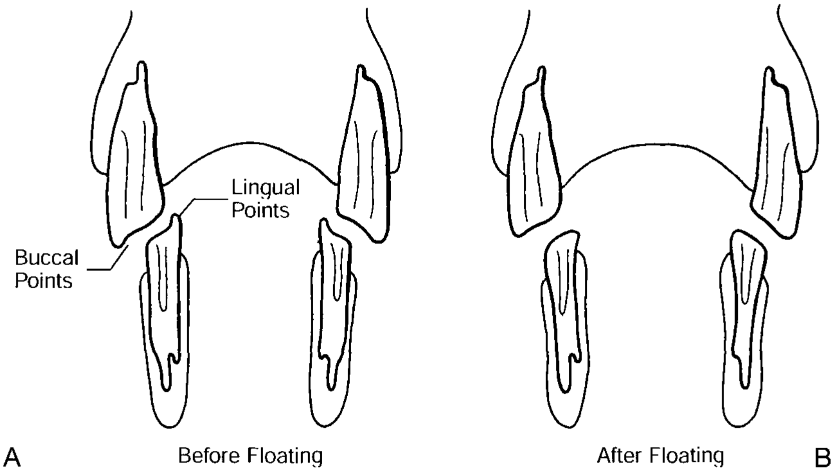


Figure 1.8 A. Cross section of head at level of cheek teeth, showing sharp enamel points. **B.** Cross section of head at level of cheek teeth, showing appearance after floating.